Geospatial Population Dynamics

DHS Advanced Scientific Computing Program

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Criticality and Limitations of Population Data

- Population data is a critical component across Homeland Security programs
- Census data limits present modeling and simulation efforts
  - Spatial resolution (Blocks are often too big)
  - Temporal resolution (Census is residential/nighttime)
- Multi-simulation environments need to utilize population dynamics
  - Function of space and time
  - Geographically scalable and deployable
  - Interoperable among simulation environments

LandScan Global Population

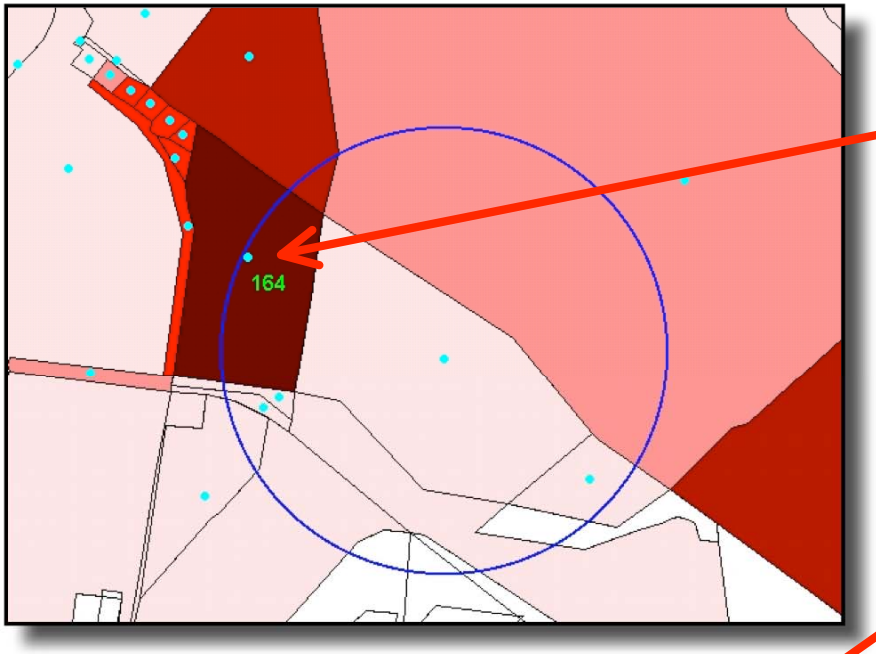
Innovative approach using GIS and RS techniques to produce world's finest population distribution model and database

- Finest spatial resolution (<1km) global population distribution ever produced
- Global coverage in consistent raster (GIS) format
- Regular (yearly) updates
- First to employ satellite imagery worldwide
- Allows quick and easy assessment, estimation, and visualization of population at risk
- Integrated with transportation, socioeconomic, and consequence assessment models (HPAC, NARAAC)

- Accepted standard for estimating population at risk by the DoD
- Federal agencies including DoD, DoS, DHS (FEMA, TSA), DOE, USGS, NASA, EPA, and HHS (CDC, NIH) are current users of the data for research and development and routine exercises
- Over 1200 non-defense registered users worldwide including WHO and the UN agencies
- Used in Rand McNally's World Goode's Atlas and National Geographic Maps

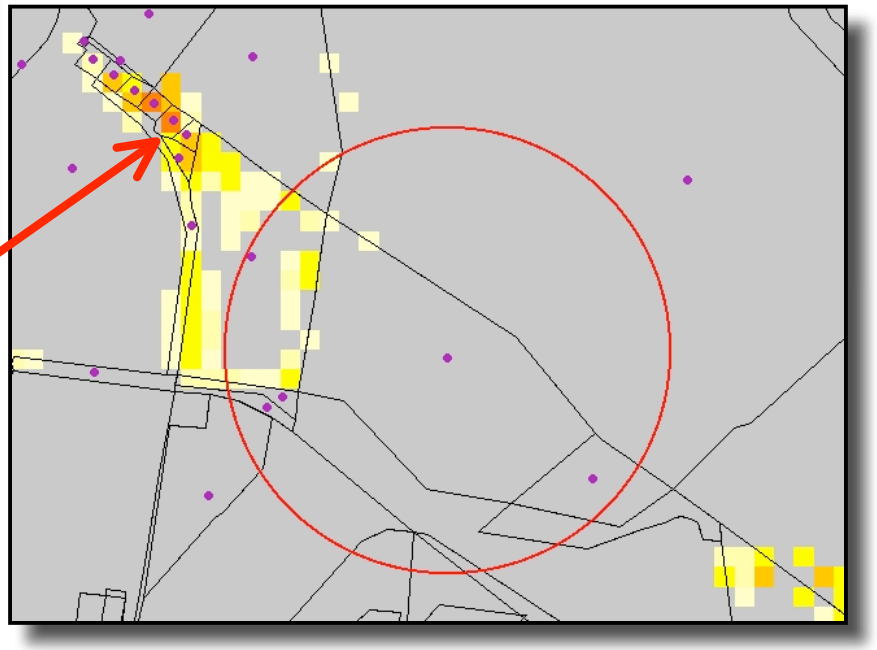
LandScan and Census

Census



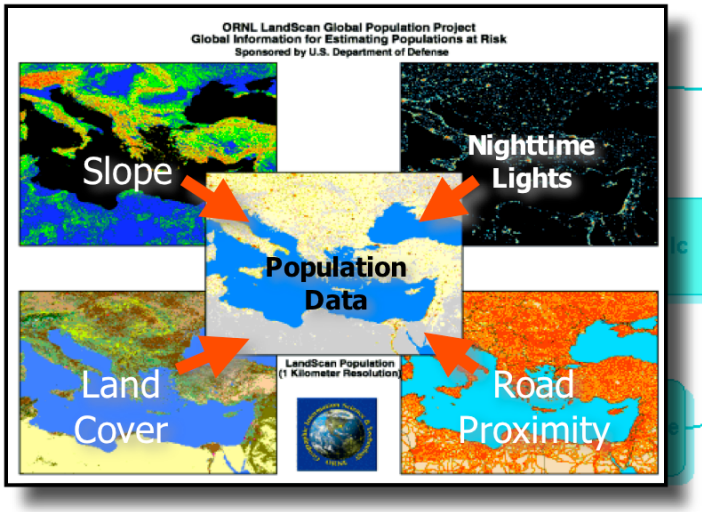
Uniform distribution assumed and all attributes associated with Census polygon centroid

LandScan



More realistic non-uniform distribution of population with attributes associated with individual LandScan cells

How Is LandScan Developed?



- Dasymetric Spatial Modeling
- Distribute best available census counts to LandScan cells based on a likelihood coefficient calculated by this model
- Model structure is the same everywhere, but weights and scores for each variable are tailored to each region (Block for LandScan USA)

H	H	H	L	L	F
H	H	H	L	F	W
H	L	L	L	F	W
H	L	F	W	W	W
L	L	F	W	W	W
L	F	F	W	W	W

H: High Density Residential
L: Low Density Residential
F: Evergreen Forest
W: Water

150	150	150	90	90	4
150	150	150	90	4	0
150	90	90	90	4	0
150	90	4	0	0	0
90	90	4	0	0	0
90	4	4	0	0	0

Aggregated to Coefficient Cell Size

1230	372
526	0

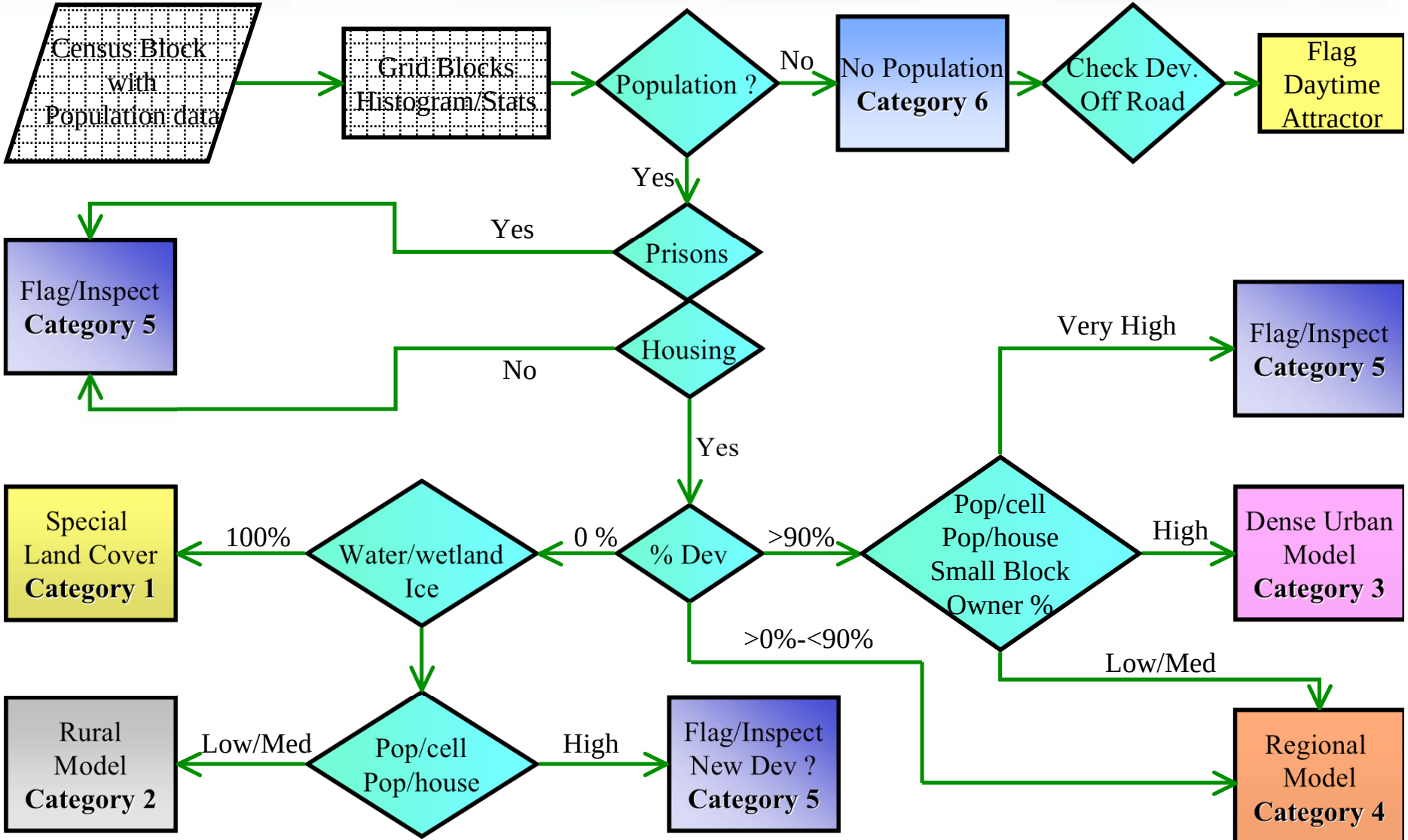
325	63
112	0

3250	630
1120	0

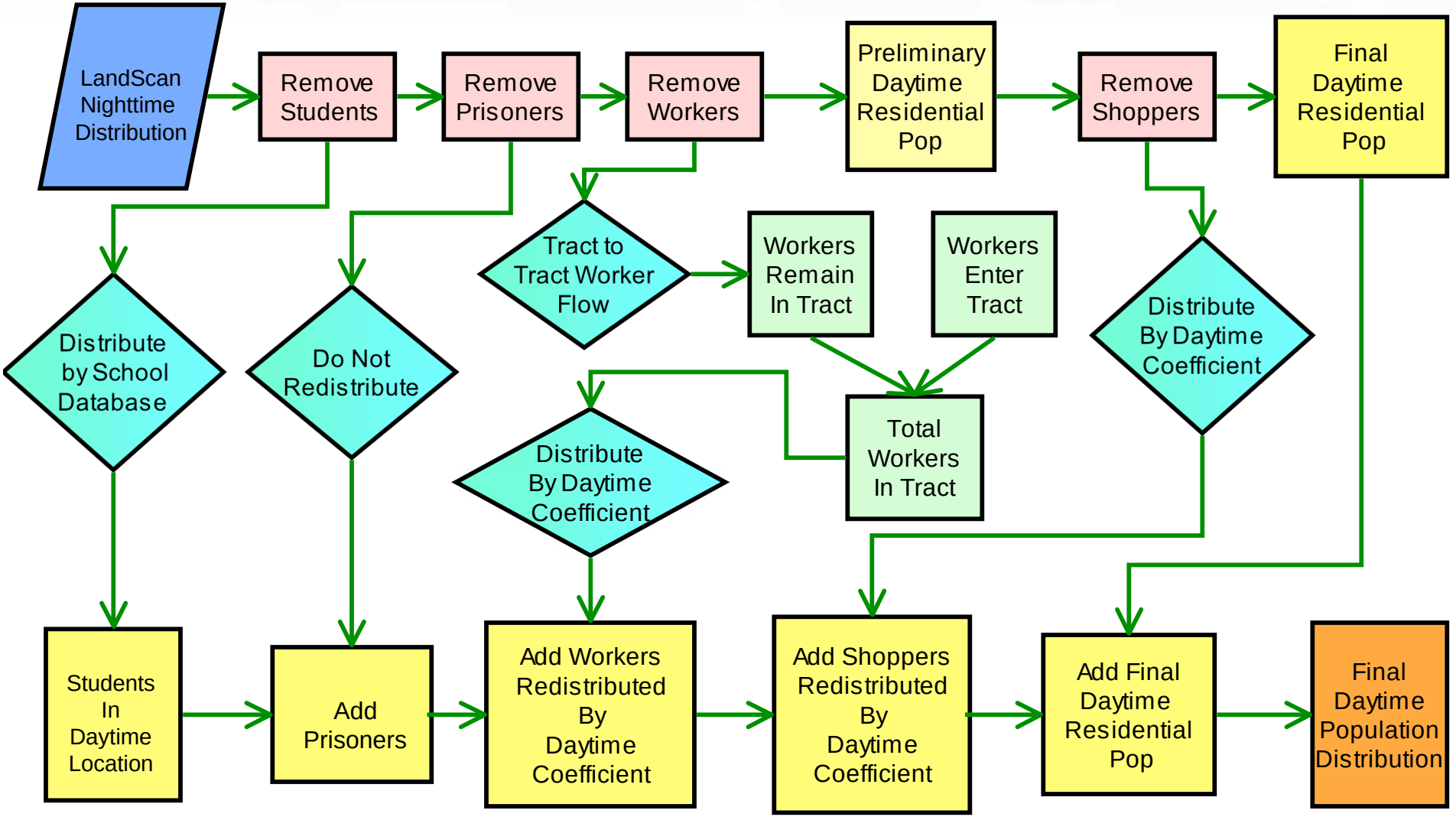
Input Data Smorgasbord

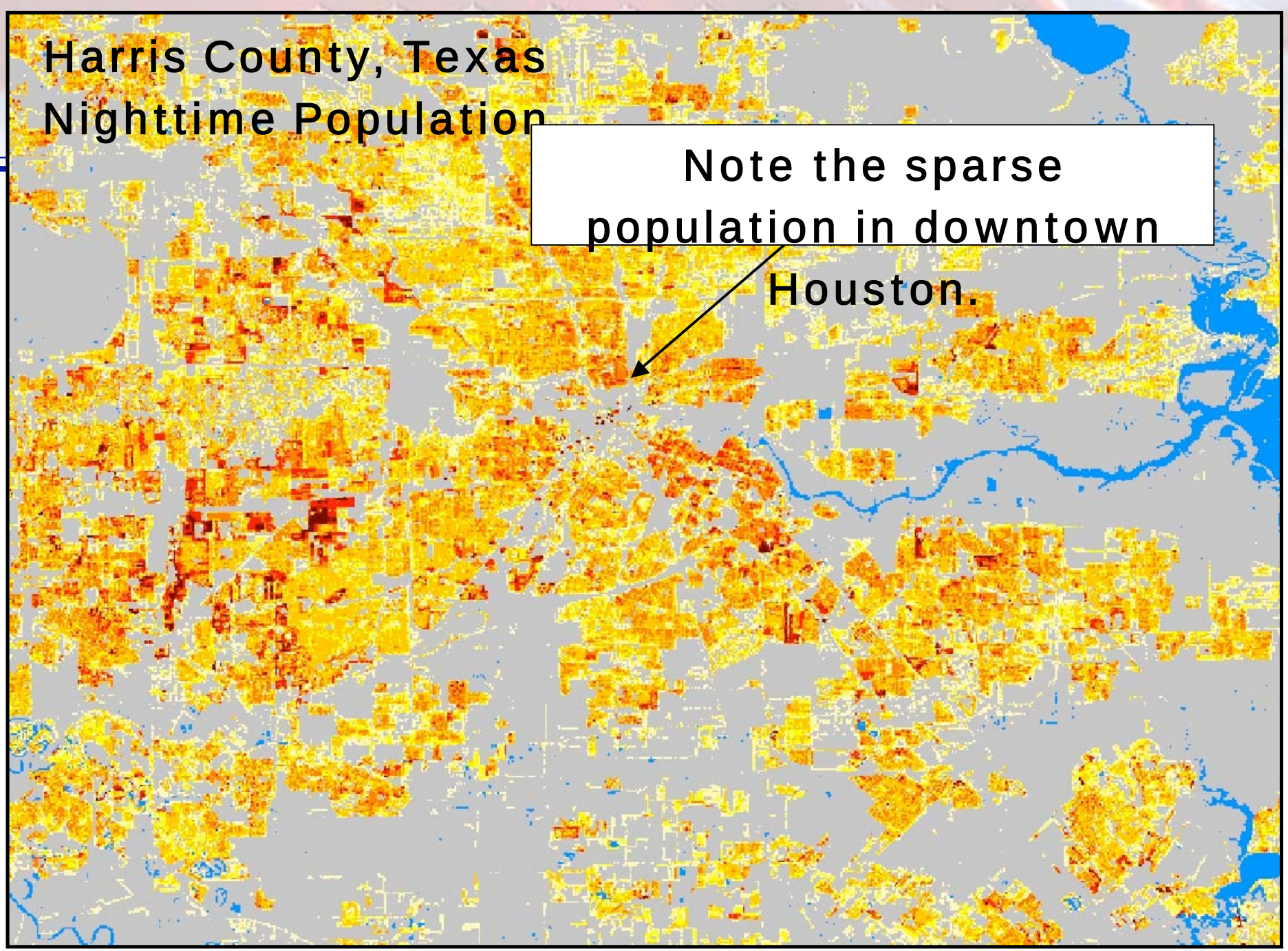
- Population
  - Census Block; Tract-to-tract worker flow; BLS quarterly updates.
- Roads
  - GDT Dynamap; TIGER;
- Land Cover/Land Use
  - National Land Cover Data (NLCD); State GIS;
- Slope
  - National Elevation Data (NED)
- Academic Institutions
  - Department of Education; ESRI; GDT;
- Prisons
  - National Jail Census
- Hospitals
  - American Hospital Association (AHA)
- Business Employment
  - InfoUSA
- Ortho Imagery
  - EarthViewer; Terra Server.

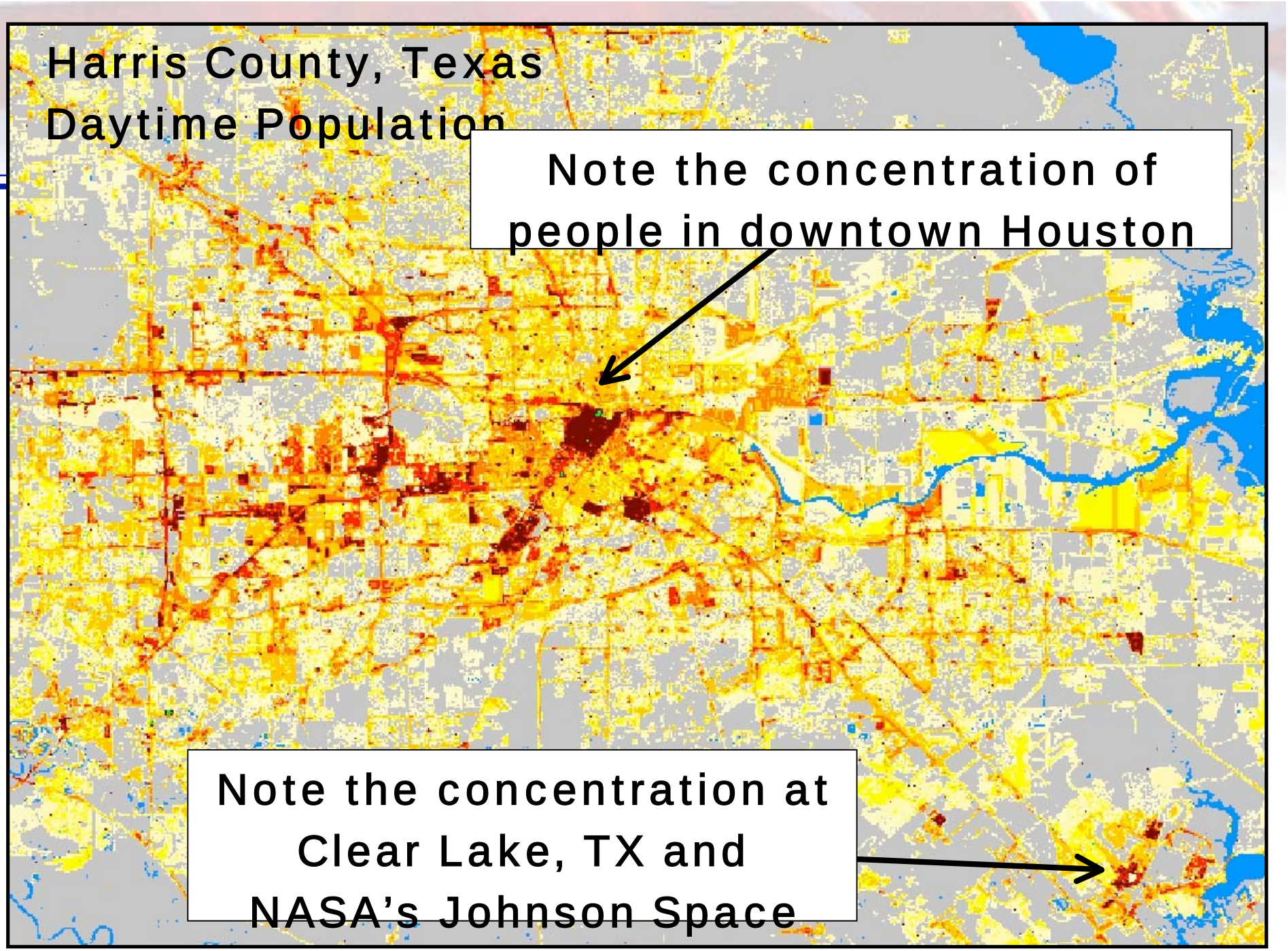
LandScan USA Nighttime Census Block Characterization

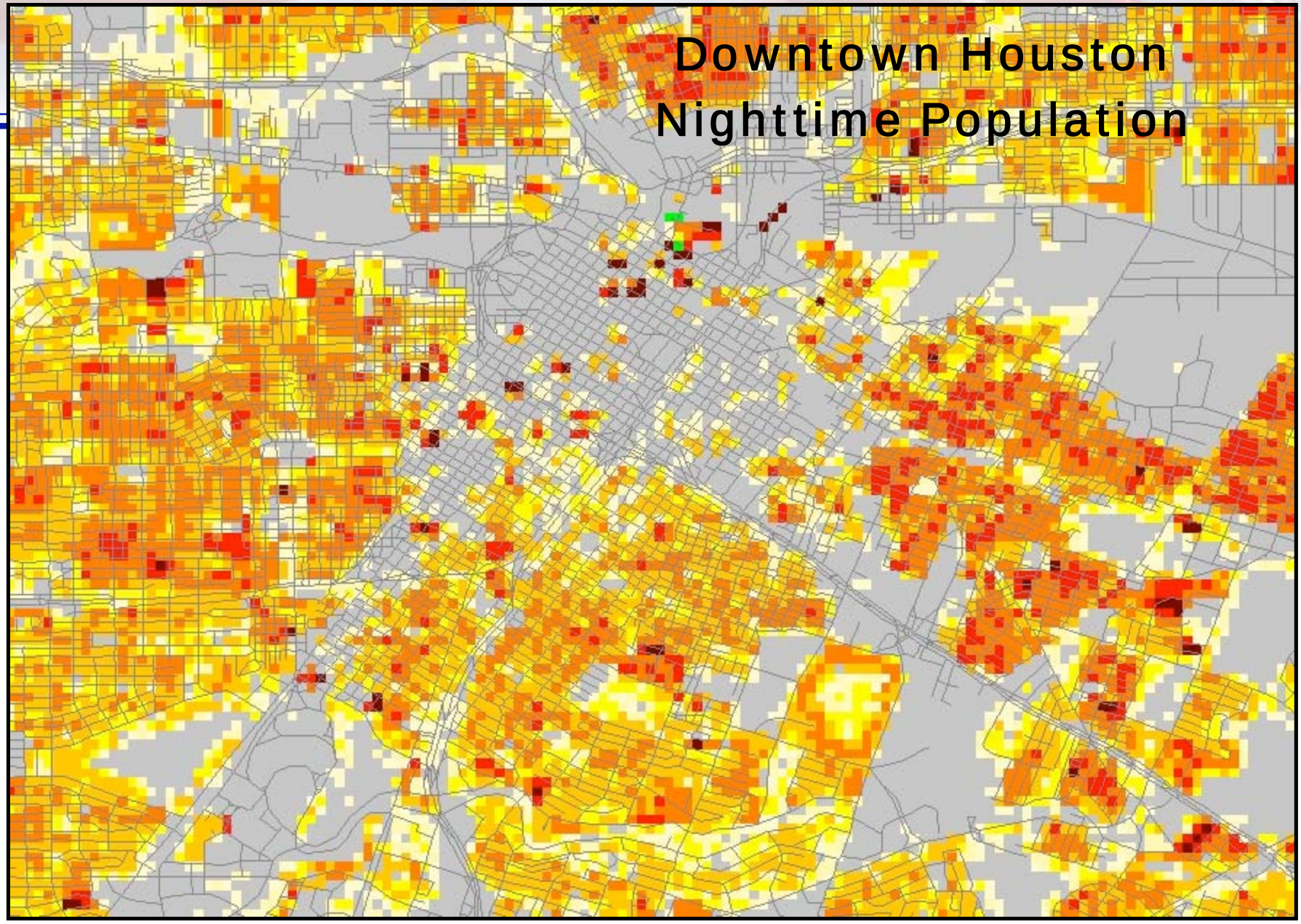


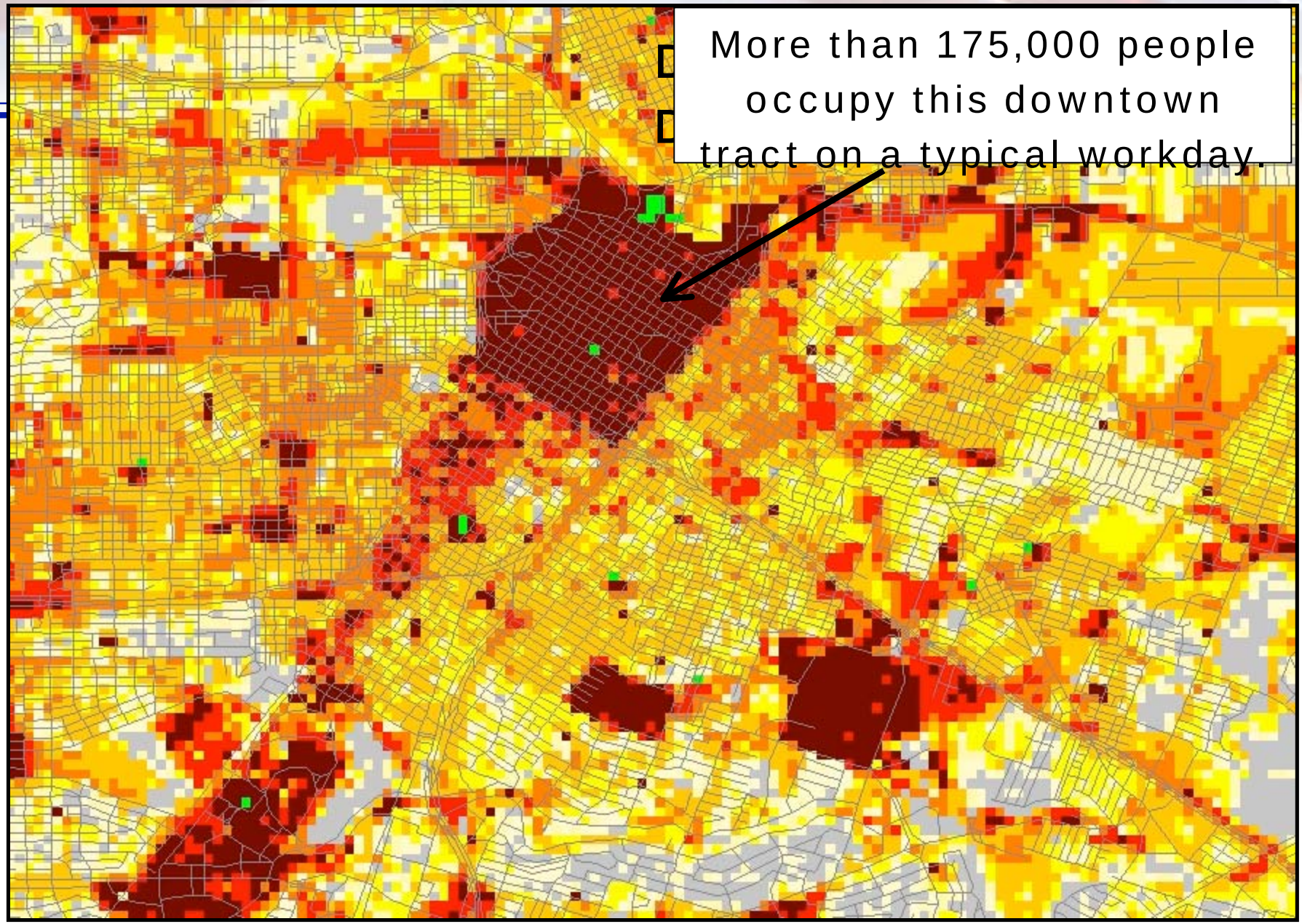
LandScan USA Daytime Characterization

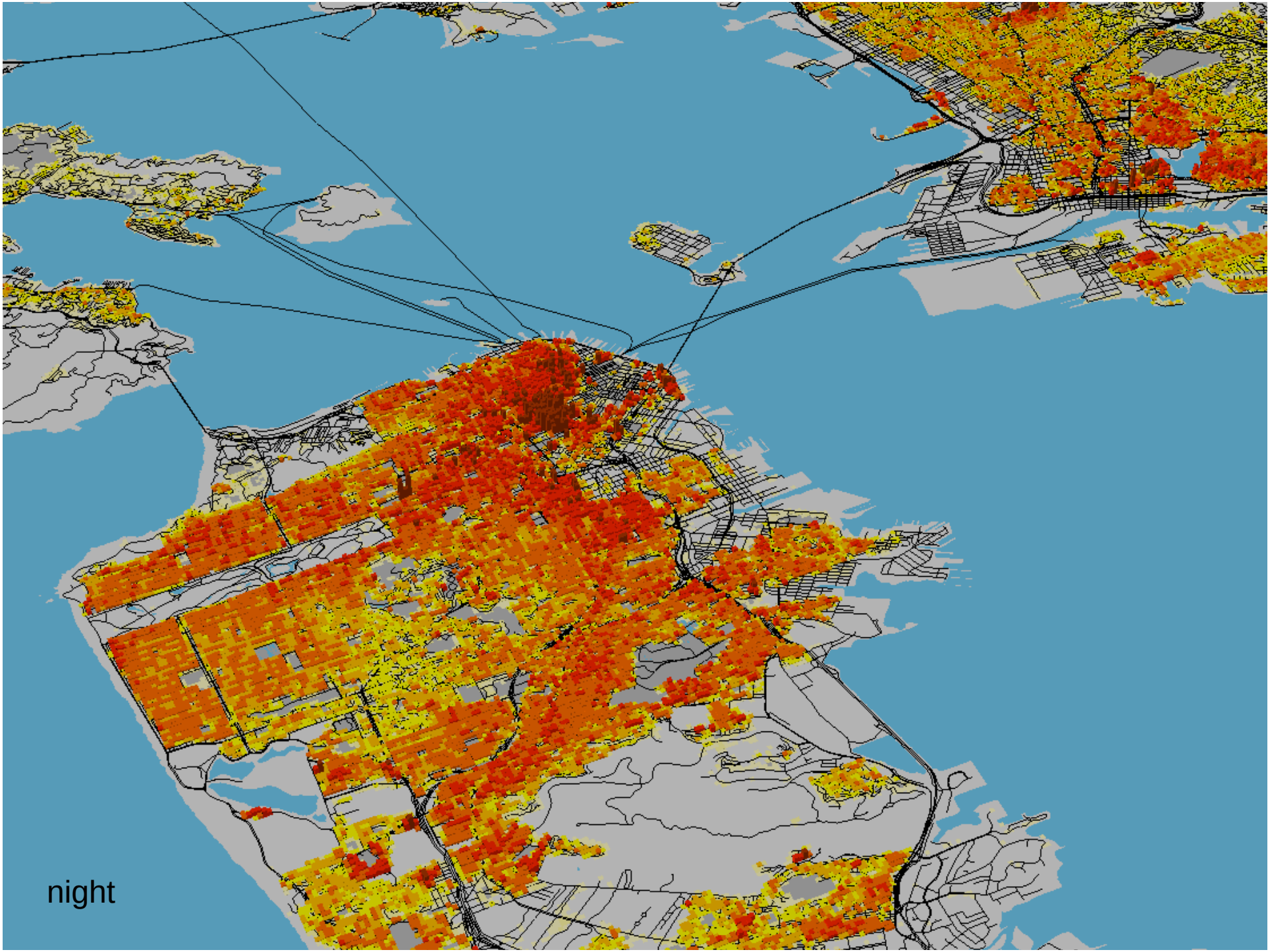


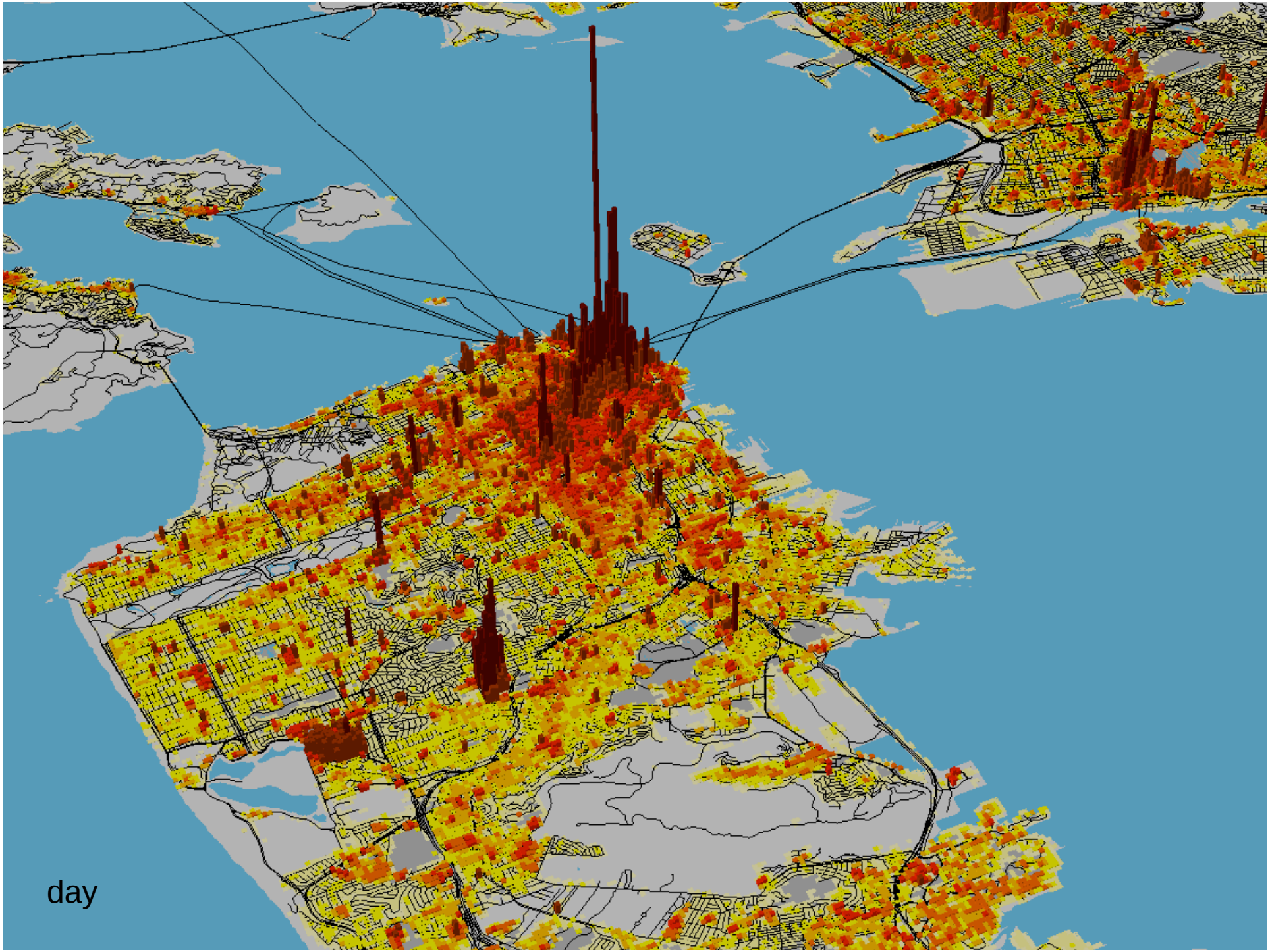

Harris County, Texas
Nighttime Population
Note the sparse population in downtown Houston.


Harris County, Texas
Daytime Population
Note the concentration of people in downtown Houston
Note the concentration at Clear Lake, TX and NASA's Johnson Space Center

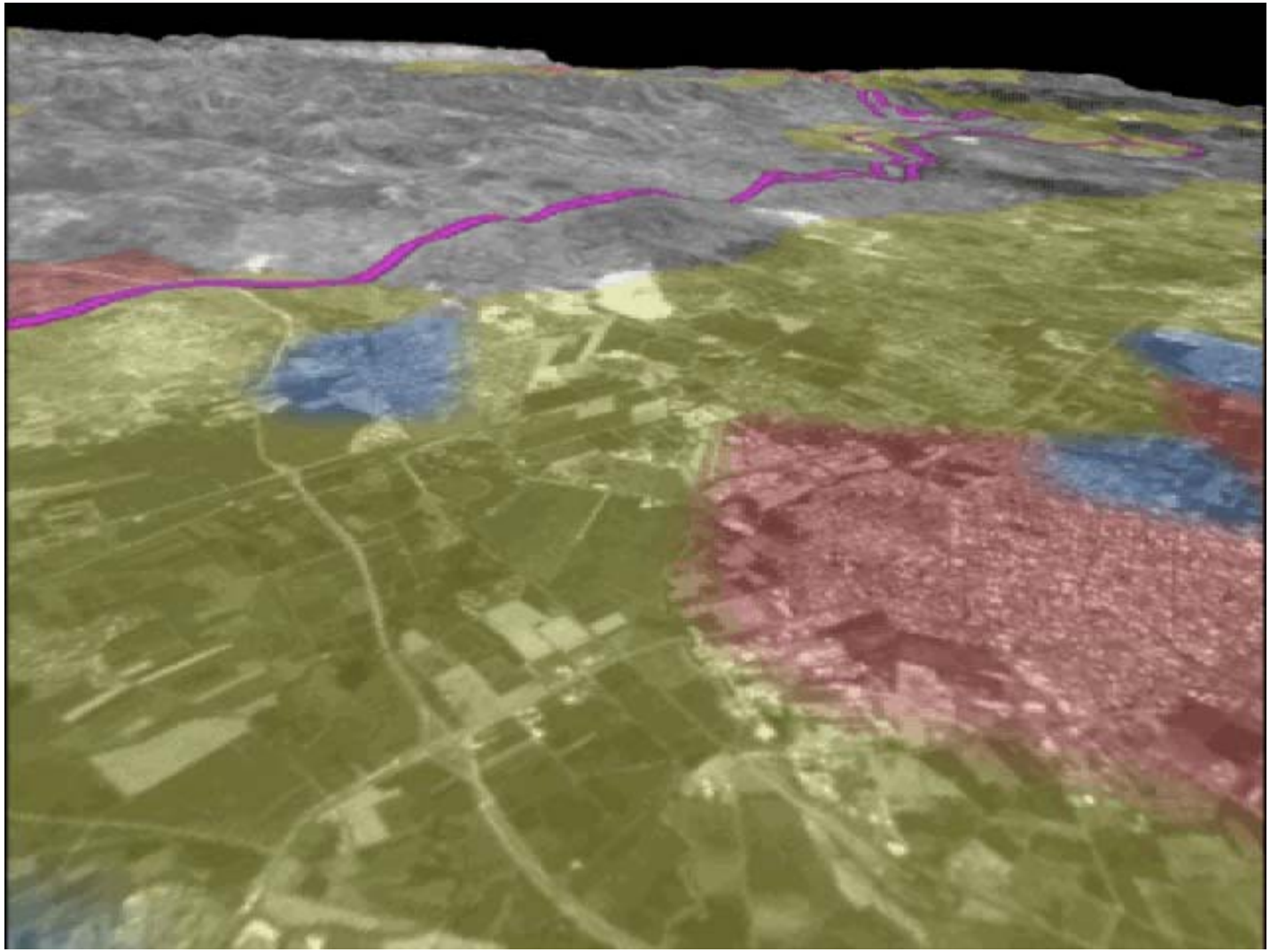

Downtown Houston
Nighttime Population


More than 175,000 people occupy this downtown tract on a typical workday.

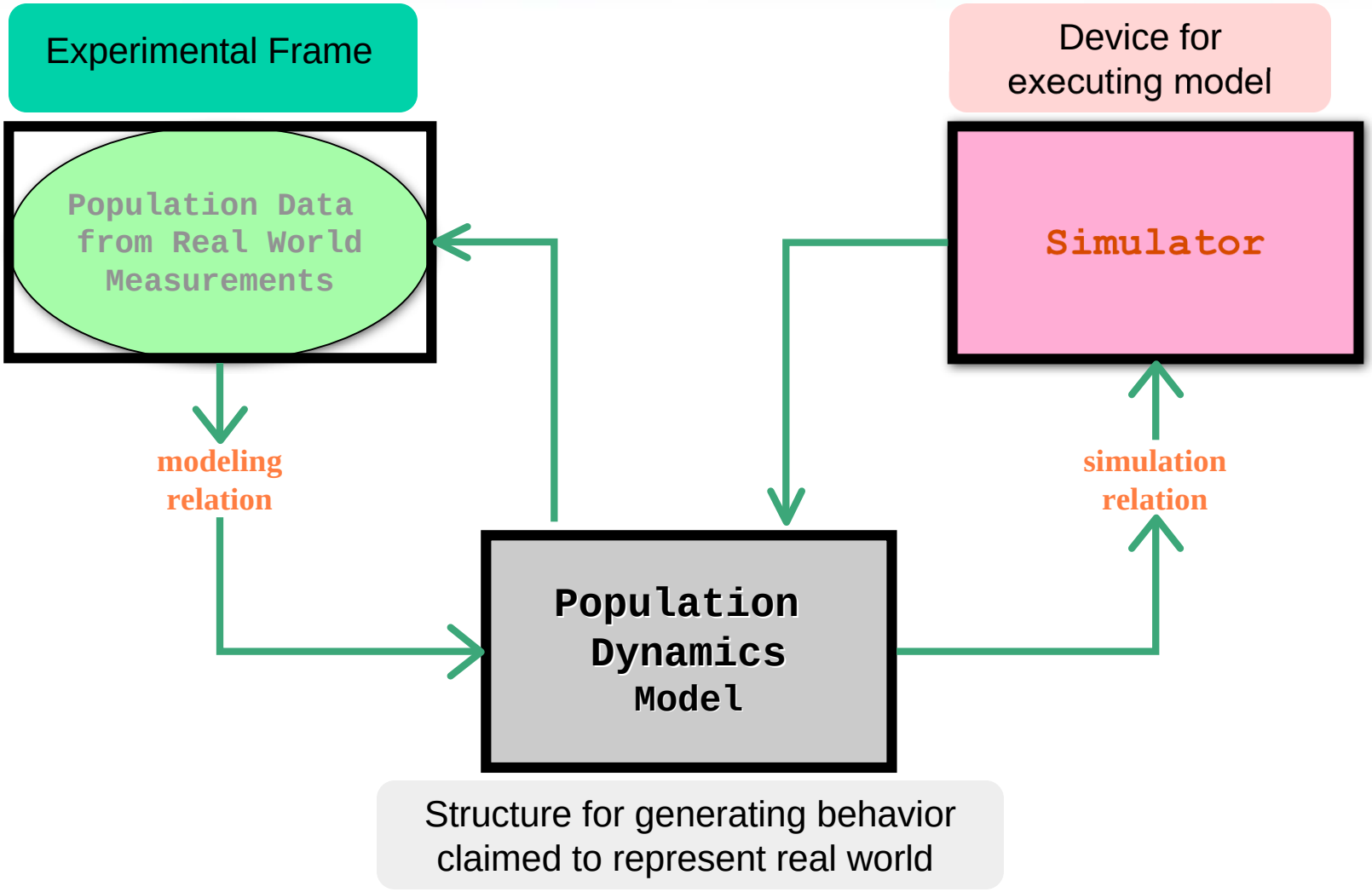

night


day

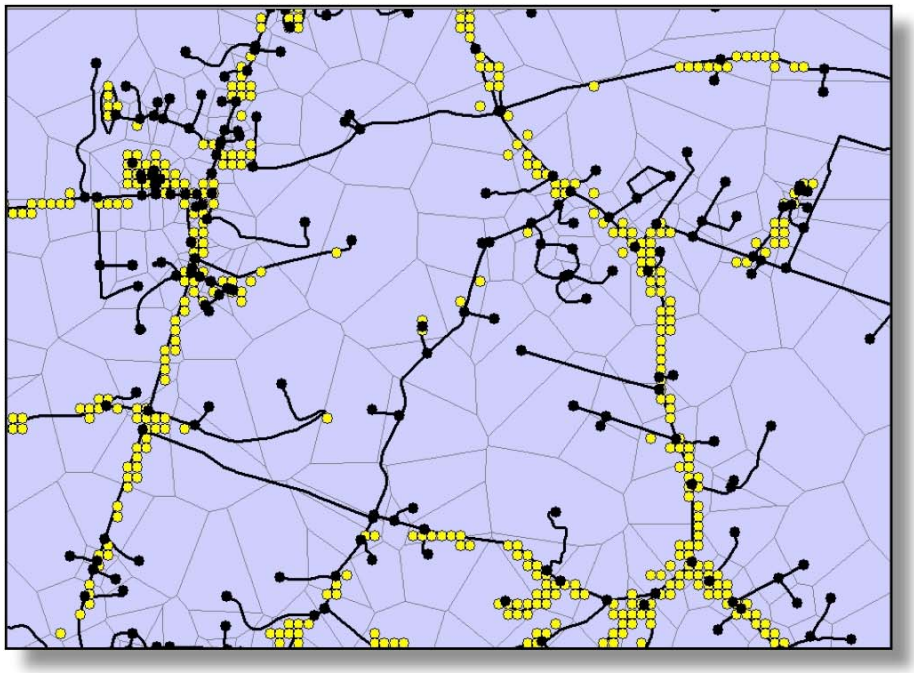
Space-Time Visualization

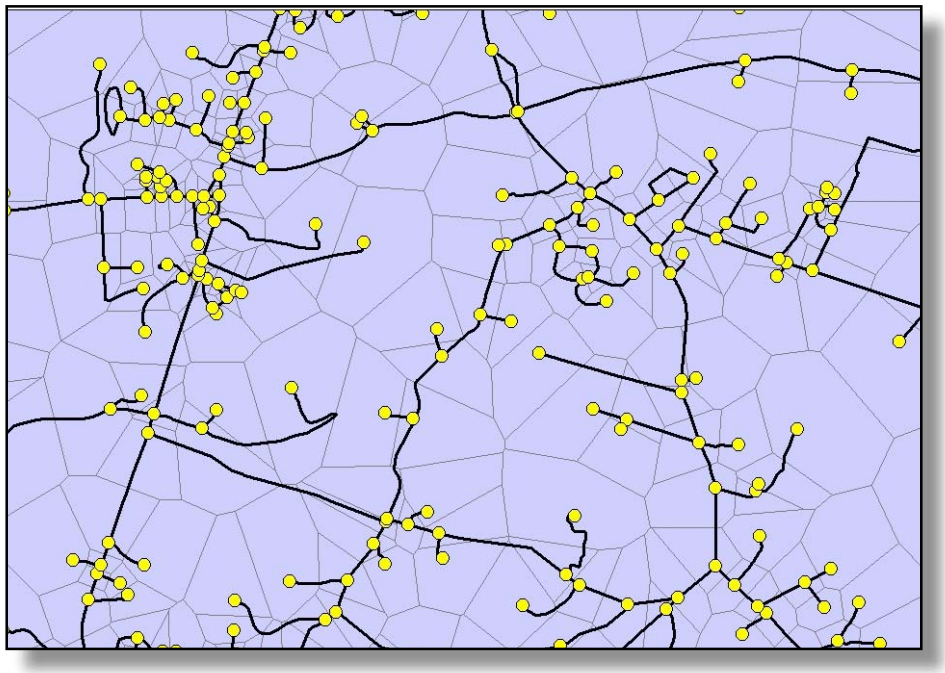


Modeling & Simulation Framework



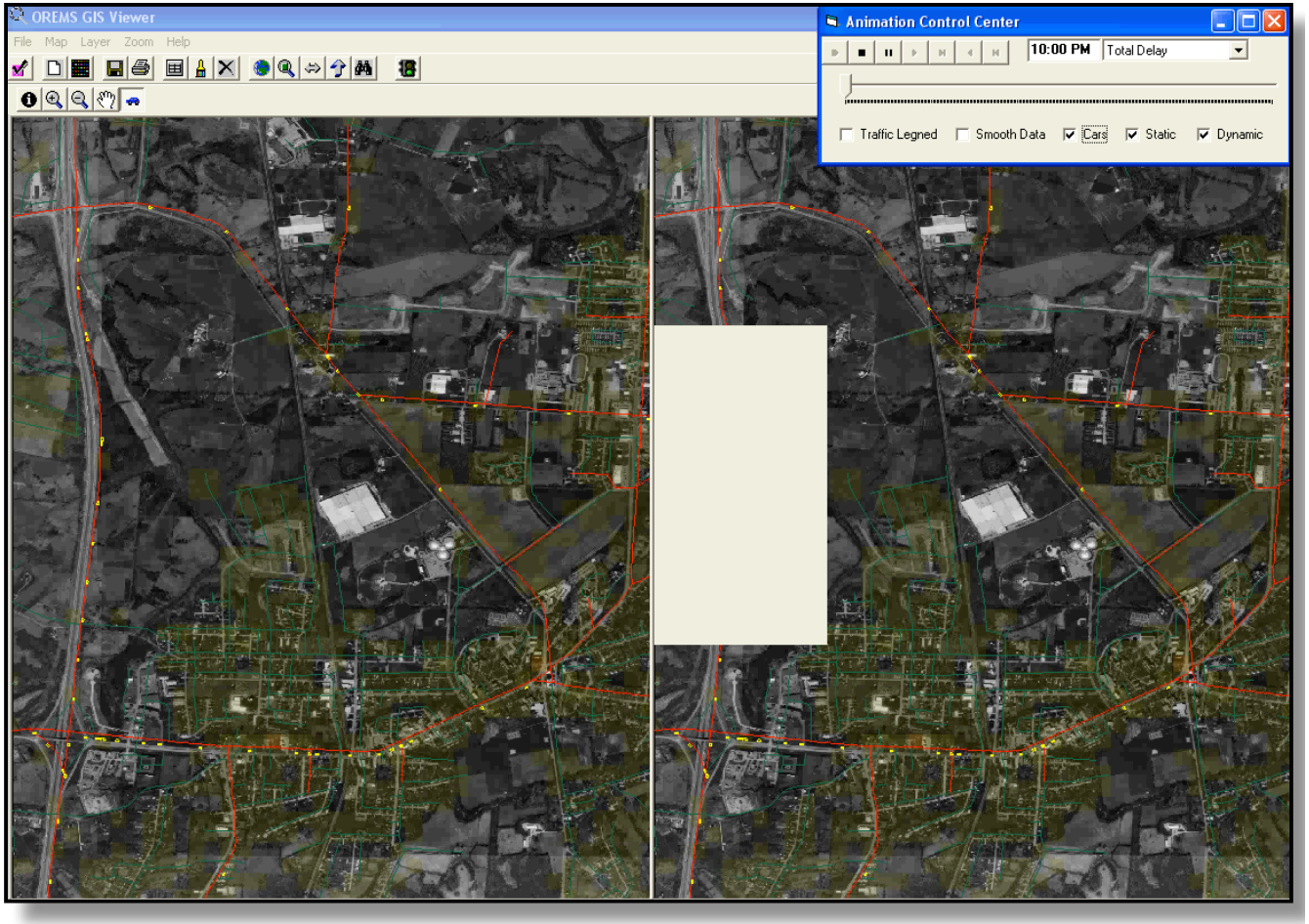
Population Allocation Model for Transportation





Intelligent Consequence Management

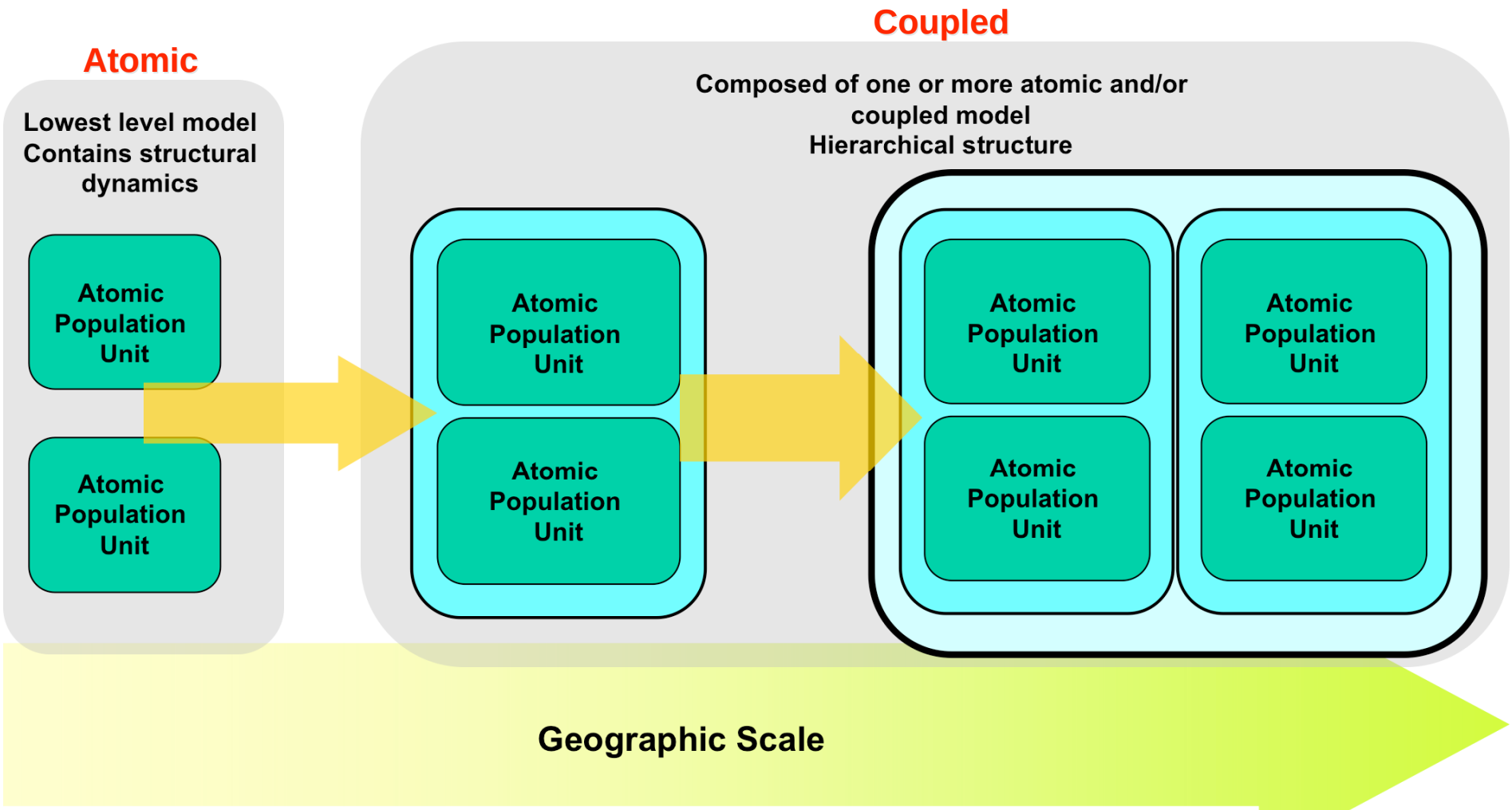
- Real time consequence analysis
- Compounding effects from disasters
- Dynamic traffic assignment
- GIS-data integration
- Sensitivity of lead time



Approach

- **DEVS = Discrete Event System Specification**
  - Based on formal M&S framework
  - Derived from mathematical dynamical system theory
  - Supports hierarchical, modular composition
  - Object oriented implementation
  - Supports discrete and continuous paradigms
  - Exploits efficient parallel and distributed simulation techniques

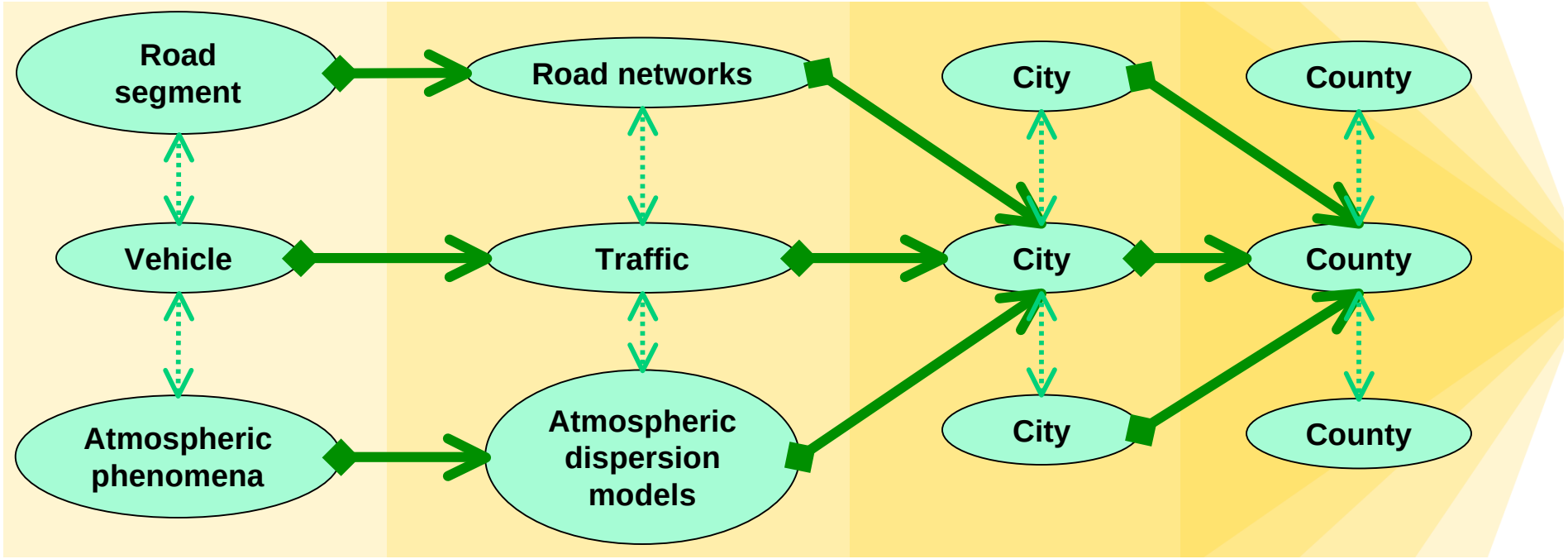
DEVS Hierarchical Modular Composition



DEVS Expressivity

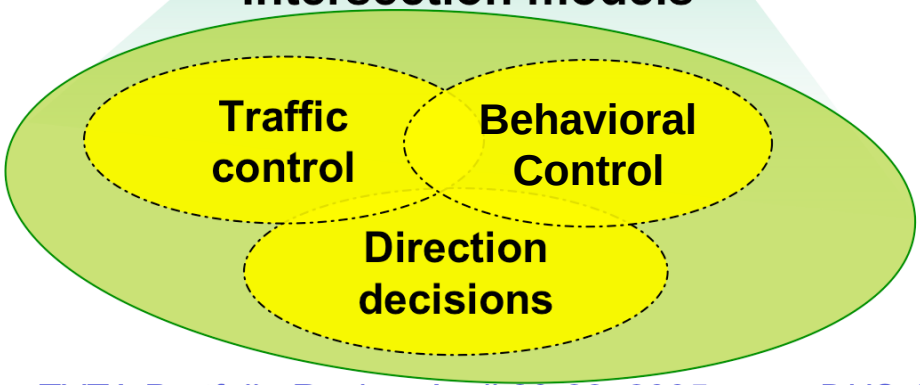
Atomic Model

Coupled Model

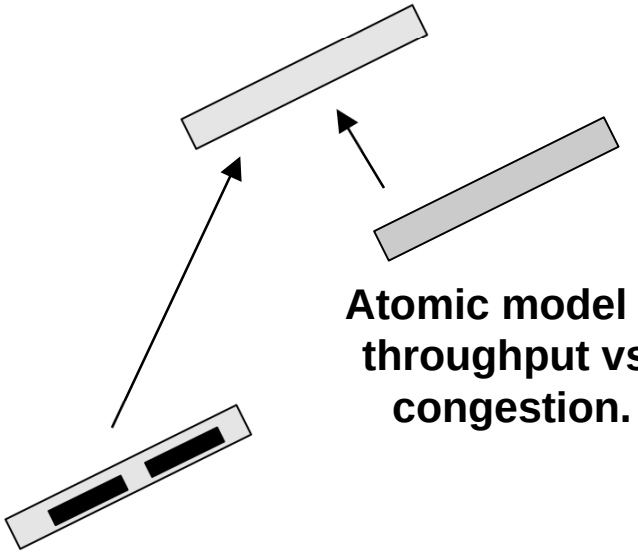


Dynamic population modeling with hierarchical, modular models

Intersection models

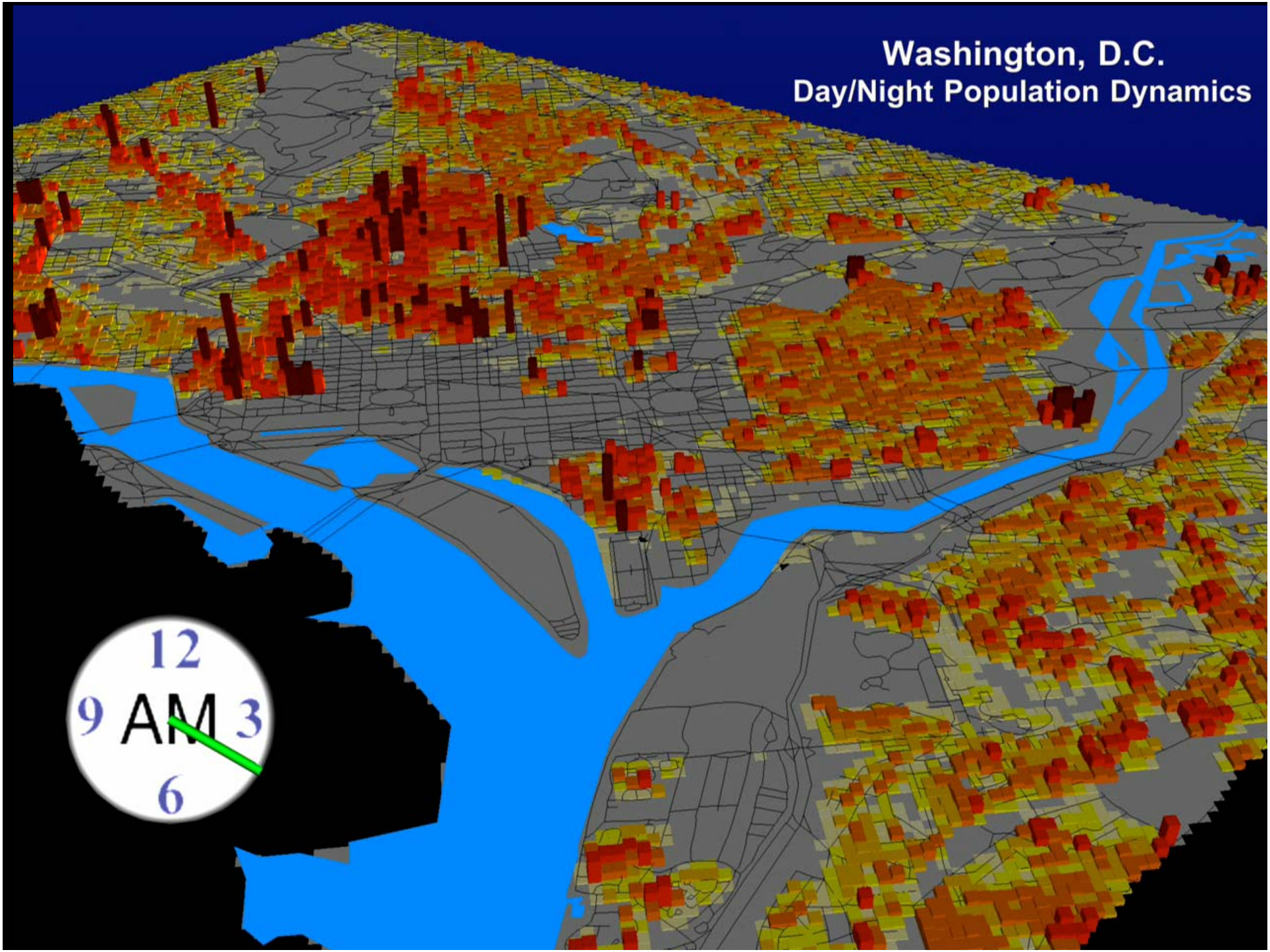


Model of link dynamics

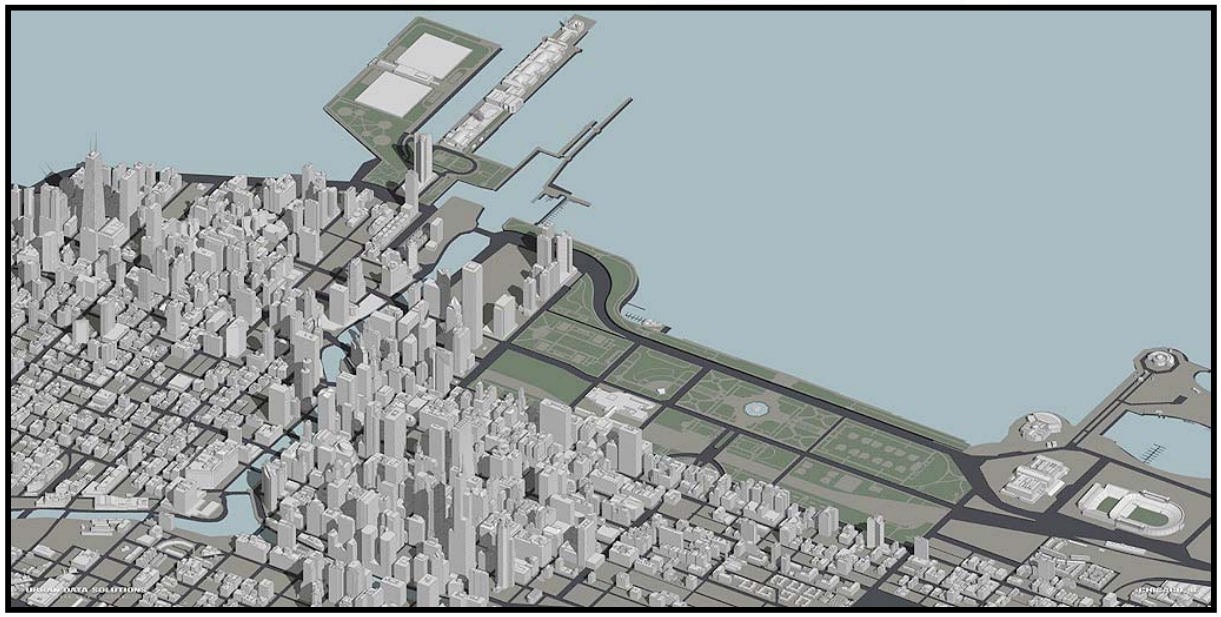


Atomic model of throughput vs. congestion.

Coupled model describing individual cars on small road segments.


Washington, D.C.
Day/Night Population Dynamics
12
9 AM 3
6

Near-Real Time Population Model



Combining

- Image processing
- GIS modeling
- High-performance computing